SEVEN MILE BRIDGE
Yellowstone Roads and Bridges
Spanning Gardner River on Grand Loop Road
Yellowstone National Park
Park County
Wyoming

HAER No. WY-28

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16-

BLACK & WHITE PHOTOGRAPHS

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Historic American Engineering Record
National Park Service
U.S. Department of the Interior
P.O. Box 27377
Washington, DC 20013-7127

Rocky Mountain Regional Office
National Park Service
U.S. Department of the Interior
P.O. Box 25287
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HISTORIC AMERICAN ENGINEERING RECORD

SEVEN MILE BRIDGE

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Location:	Spanning Gardner River on Grand Loop Road, 9.5 miles south of Mammoth Hot Springs, Yellowstone National Park, Park County, Wyoming UTM: Mammoth, Wyoming Quad. 12/521280/4970110
Date of Construction:	1932
Owner:	Yellowstone National Park, National Park Service
Use:	Vehicular bridge
Designer:	General plans and specifications by G.M. Williams, Bureau of Public Roads
Builder:	Stevens Brothers, St. Paul, Minnesota
Significance:	Seven Mile Bridge typifies the early design philosophy of the National Park Service, which was to use indigenous materials to harmonize man-made features with their natural surroundings. This philosophy is embodied in many of the park's Rustic Style buildings and structures.
Project Information:	Documentation of Seven Mile Bridge is part of the Yellowstone Roads and Bridges Recording Project, conducted during the summer of 1989 by the Historic American Engineering Record, a division of the National Park Service, under the co-sponsorship of Yellowstone National Park, the NPS Roads and Bridges Program, and the NPS Rocky Mountain Regional Office, Denver. Historical research and written narrative by Mary Shivers Culpin, Historian, NPS Rocky Mountain Regional Office. Engineering description by Steven M. Varner, Virginia Polytechnic Institute. Edited and transmitted by Lola Bennett, HAER Historian, 1993.

HISTORY OF GRAND LOOP ROAD

(See HAER WY-24, Yellowstone Roads and Bridges.)

HISTORY OF GRAND LOOP ROAD: MAMMOTH HOT SPRINGS TO MADISON JUNCTION

In 1877, Yellowstone Superintendent Philetus Norris proposed construction of a bridle-path from Mammoth Hot Springs to the Firehole River region via Gardner Falls and Gibbon River which would connect the only two entrances to the park, on the west and north boundaries. This proposal was part of a larger scheme which included construction of a wagon road from Mammoth Hot Springs to Henry's Lake via Tower Falls, Mount Washburn, Yellowstone Falls, Lake Yellowstone, Firehole Basin, and the geyser basin region. Norris felt that the wagon road would connect the major points of interest as well as the two entrances into the park. In addition to the Mammoth Hot Springs to Firehole bridle-path, another bridle-path was proposed from Stillwater River to Upper Geyser Basin via Clark's Fork mines, Soda Butte, the petrified forests, Amethyst Mountain, Pelican Creek, Shoshone Lake, and Old Faithful geyser. Norris also planned to build facilities at Mammoth Hot Springs.

Upon arriving in the park the following year with the first Congressional appropriation of $10,000, Norris' priorities for building facilities and constructing a wagon road were changed due to the previous year's conflict with the Nez Perce Indians and a continual threat from the Bannock Indians. Instead, Norris began construction of the first permanent road in the park, from Mammoth Hot Springs to Lower Geyser Basin. Completion of the road would facilitate the military movements from Fort Ellis, Montana, to Henry's Lake, Idaho, or Virginia City, Montana; it would also be used by the ever-increasing number of visitors to the park.[1]

Prior to his explorations for appropriate routes, Norris viewed possible routes from the top of Sepulcher Mountain. He could spot the route that he had taken in 1875 and he visualized a route to the south through the park via Gibbon Canyon, Firehole Basin, the Continental Divide and on to the Tetons. Construction through the canyons could prove difficult and dangerous, but it appeared to be the most straightforward and practical wagon route.[2] Furthermore, the presence of huge masses of obsidian at Obsidian Cliff posed problems for road construction.

In the survey of the road section immediately south of Mammoth Hot Springs, Norris located three possible routes from Mammoth Hot Springs to the plateau near Swan Lake. One route, the longest and most precipitous, followed Gardner Canyon over the pass via Osprey Falls and Rustic Falls to the plateau (later known as Bunsen Peak Road); another route, which had a more gradual grade but also a sheer wall section to be traversed, was the opening created by Glen Creek on to Swan Lake; the third and chosen course was the most direct route--although it contained steep grades--through Snow Pass above the hot spring terraces. Of this section, a visitor once remarked, "So steep is the climb that if the tail-board of a wagon falls out . . . the whole load is promptly dumped out in the road. A good road, though, a longer one, might have been built over the same ground."[3]

No great construction difficulties were encountered from the flat area near Swan Lake to Obsidian Cliff; however, penetrating the "glass mountain" (Obsidian Cliff) took ingenuity. Norris described his technique:

> Obsidian there rises like basalt in vertical columns many hundreds of feet high, and countless huge masses had fallen from this utterly impassable mountain into the hissing hot-spring margin of an equally impassable lake, without either Indian or game trail over the glistening fragments of nature's glass, sure to severely lacerate. As this glass barricade sloped from some 200 or 300 feet high against the

> cliff at an angle of some 45 degrees to the lake, we ... with the slivered fragments of timber thrown from the height ... with huge fires, heated and expanded, and then, ... well screened by blankets held by others, by dashing cold water, suddenly cooled and fractured the large masses. Then with huge level steel bars, sledge, pick and shovels and severe laceration of at least the hands and faces of every member of the party, we rolled, slid, crushed and shoveled one-fourth of a mile of good wagon-road midway along the slope; it being, so far as I am aware, the only road of native glass upon the continent.[4]

Leaving Obsidian Cliff, the 1878 road followed in an southeasterly direction to Lake of the Woods and Solfatara Creek into Norris Geyser Basin. Norris' road proceeded through Elk Park, Gibbon Meadows into Gibbon Canyon. At an approximate point where Gibbon River flows in a westerly direction, the road left the canyon in a gap between cliffs and traversed pine covered slopes connecting with the Madison Junction to Old Faithful road south of present-day Madison Junction.

During 1879, Norris supervised improvements to the grades at Obsidian Cliff, in the Norris area and Gibbon Canyon. He found spanning Gibbon, Firehole and Madison rivers and their streams could prove a challenge. He wrote, "Few of the anomalous features of the *Land of Wonders* are of greater scientific interest or of more practical value than the placid, uniform water-flow in its hot spring and geyser-fed rivulets and streams." Because these water courses were generally "broad, shallow, grassy and flowers carpeted to the water's brim, ... with long stretches of flowing grass and occasional hot spring pools in the channels, ... with overhanging turfy banks," Norris decided that some of the streams could be crossed with fords, rather than bridges. Instead of a bridge he placed "long, limber poles and foot-logs, only a few inches above the low stage of water."[5]

The following season, bridges were built to span Gardner and Gibbon rivers, including costly, long causeways, turnpikes and grades along the Norris fork of Gibbon River. An extension of the road to the Forks of Gardner River was finished and a road "through the eastern branch nearly half-way through its terrible canyon, necessitated a grade of over 1,000 feet within two miles."[6]

In 1882 the new superintendent, Patrick Conger, who accomplished little in the way of road construction, was responsible for the construction of a bridge over Gardner River. Construction was supervised by Captain E.S. Topping. The bridge, located twelve miles south of Mammoth Hot Springs, was built in just two weeks. The 96-foot structure had abutments extending well out into the river on both sides. The center pier and the abutments were constructed of logs in a V-shaped configuration, pinned at the corners and filled with rock above the high water mark. The bridge was covered with 5"-thick hewn logs.[7] Topping and his crew also built and repaired culverts and crossways, removed rocks and boulders, and still Conger wrote "Our road is still in a mountainous and rugged country, requiring much labor and expense before it can be said to be a good road." In his appeal for more appropriations for road work, he described the situation:

> When you consider the extent of the territory and the great natural obstructions that have to be encountered, it seems to me it must be evident, ... the amount heretofore placed at the disposal of the Secretary of Interior 'for the protection and improvement of Yellowstone National Park' is entirely inadequate. ... But to proceed with our road we have to pass over some very high hills to reach the valley of the main Gibbon, where we encounter a wide low bottom called the Geyser

> Meadow, a place where it will require a large amount of labor to make a good road. After passing the meadow our road enters the Gibbon Canyon and follows the river down several miles, close on the edge of the stream, crossing the same three times in as many miles over difficult and dangerous crossings in time of high water. After passing through this canyon our road gains the highlands, by a steep grade along the side of the mountain on the south side of the river. We soon come to the great falls of the Gibbon where the river plunges over a perpendicular precipice of 75 feet, which in the stillness of the evergreen forest that covers this country renders the scene as enchantingly beautiful as 'fairyland'.[8]

Army engineer Lt. Dan Kingman, who assumed the responsibility for road construction in the park in 1883, found this section of road to be the most heavily traveled in the park and in the worst condition. His largest work crews reported there until heavy snows of 18" to 30" during the middle of October 1883. With the exception of a three-mile section in Gibbon Canyon, this forty-mile section was widened and straightened, boulders and stumps removed and slopes reduced. Frequently-spaced turnouts and a new ford were built. Existing bridges were repaired and the corduroy sections were covered with sod and earth. Work on this section cost approximately $6,300, or $170 per mile.

In 1885 major projects and changes were made to the section of road from Mammoth Hot Springs to Firehole Basin. Several bridges were completed, one over Gardner River at the ford, and two over Gibbon River.

Work was completed on the new route immediately south of Mammoth Hot Springs. This 4½-mile section from Mammoth Hot Springs to Gardner via Golden Gate and the West Fork of Gardner River, was started in 1883 and completed in seven months. Workers used 1,275 lbs. of explosives, and fired 1,300 shots in drilled holes. As a result, 14,000 cubic yards of solid rock was excavated in addition to a large amount of broken and crushed rock. As a credit to the workmen, this dangerous section of road was completed without any injury of loss of life. The completion of this section reduced the route by 1¼ miles and the time to many areas in the park from two hours to a half-day, depending on the type of wagon and load. The reduced ascent of 250 feet to Swan Lake plateau enabled loaded wagons traveling in opposite directions to reach Snow Pass with relative ease. The near-vertical stone walls of the canyon prevented construction of an excavated roadway, thus a 228-foot wooden trestle carried the roadway. Lt. Kingman noted in his report for 1885, "[a] natural stone monument at the end of the trestle [marked what] visitors have called the Golden Gate."

Kingman established a road camp near Norris Geyser Basin in order to begin work on the new road between Norris Geyser Basin and Beaver Lake, where it would connect with the old road at the head of the lake. The poorly-located old road ran in an easterly direction south of Beaver Lake, before entering the woods near Lake of the Woods, then the road followed Solfatara Creek and crossed the Continental Divide near the confluence of the rivers near Norris Junction. Due to excessive precipitation and heavy timber cover, snow covered the road well into May. Poor surface drainage caused by heavy clay soils and the saucer-like shape of the pass produced horrible conditions for travelers. Kingman noted that it was not uncommon to see "a team lying in the mud, tangled in their harness and floundering about in almost unextricable [sic] confusion while the drivers looked on in despair." Consequently, Kingman sought a new route which would provide more exposure to the sun, and better drainage and soil conditions. The seven miles of new road, completed by the middle of October, cost $6269.80. Before the close of the 1885 season, the crews replaced "a long and rather unsafe structure built of poles [with a] single span King-post truss of 30 feet," combined with a causeway, over Gibbon River near Norris Geyser Basin.

In 1887 the wooden trestle through Golden Gate was strengthened by placing new timber supports and road-bearer cross beams. A log and pole temporary bridge had to be placed over Obsidian Creek at the ford due to unusually high runoff. Lt. Kingman's replacement, Captain Clinton Sears, proposed building a new seven-mile road from Swan Lake Flats to Beaver Lake, a new road between Norris Basin and Gibbon Canyon which would complete the six-mile gap, and a new road from Gibbon Canyon to Firehole Basin. With a small 1888 appropriation, Sears was able to build a road from Norris Hotel across Gibbon Meadow connecting with the road into Gibbon Canyon and a seven-mile stretch northward from Obsidian Cliff.[9]

In 1889 a 40-foot through truss span was built over Gardner River at the south end of Swan Lake Flats. It had a trestle span of 20', a roadway width of 14' and a height above low water of 6'-6". An 86-foot trestle bridge with a 13'-8" wide roadway between guardrails, 5'-6" above low water, was built over Gibbon River in the canyon. The engineers felt that a trestle bridge could be safely built because the river, which has many hot springs in its bed, would not receive ice build-up. Thus at the end of 1889, the following bridges were in service between Mammoth Hot Springs to Madison Junction:

1. three spans of 33' over Gardner River--no truss
2. three spans of 32' over Gardner River--King post
3. trestle of 224'--Golden Gate
4. one span of 14' over West Gardner River--no truss
5. two spans of 40' and 20' over Gardner River--King and queen-post
6. one span of 32' over Obsidian Creek--King post
7. one span of 16' over Obsidian Creek--no truss
8. one span of 32' over Obsidian Creek--King post
9. one span of 34' over Gibbon River--King post
10. one span of 20 feet over slough at Norris--no truss
11. two spans of 40 feet over Gibbon River--Queen post
12. trestle of 75' over Gibbon River--Queen post
13. one span of 24' over Gibbon River--no truss
14. one span of 24' over Gibbon River--no truss
15. one span of 20' over Gibbon River--no truss[10]

During 1890 one of two major projects in Yellowstone was construction of retaining walls in Gibbon Canyon.[11] In 1895 the Army Corps of Engineers completed another bridge over Gibbon River at an old ford, near the canyon mouth.[12] The next major road projects for this section would be a part of Captain Hiram Chittenden's 1900 multi-year plan for completion of Yellowstone's Grand Loop Road.

Among Chittenden's proposals for the multi-year project, he recommended a new widened road through Golden Gate Canyon, including a new bridge to replace the wooden trestle around the cliff, raising three miles of road 2' or 3' in Gibbon Canyon and cutting out one mile of dangerous grades, and constructing four miles of new road along Gibbon River to connect with the western entrance road.[13]

About one mile of the original wagon road along Gibbon River Canyon remained in 1900. The road had two very steep grades, one of which had a sharp curve at the bottom right at the river's bank. Chittenden found this particular stretch to be most dangerous as the failure of brakes or any other emergency might bring a team and wagon into the river. He called the road through Gibbon Canyon "one of the most pleasing in the park. It runs immediately along the bank of the river and is of easy grade. Unfortunately it is not built high enough above the river to make it safe. The river at every heavy flood goes clear over the road and has washed it out twice in the past six years." By 1903 the two bad grades had been cut out, one mile of new road had been constructed and a new steel bridge with concrete abutments had been built. During the winter of 1902, rock was hauled on sleds for about a mile to be used in the construction of the new heavy retaining wall on the newly reconstructed section of road about a half mile below Gibbon Falls.[14]

In 1904 a worn-out bridge in Gibbon Canyon was replaced with a small 45-degree-skew span. The following year, the bridge over Gibbon River near Norris Junction was reconstructed, and a steel truss was built over Gardner River at milepost-7 (Seven Mile Bridge).[15] Chittenden completed construction work on the Golden Gate during 1902.[16]

Before Captain Chittenden left Yellowstone to begin supervision of the roads in Mount Rainier, he made the following recommendations for improvements on the Mammoth Hot Springs to Madison Junction road:

> Great care should be taken in widening the road through the "Hoodoos" to prevent the destruction of unusual rock formations. It will be better to let the right of way have an irregular alignment--being narrower in some places than in others--than to sacrifice this peculiar formation in order to get a uniform width throughout. ... it would be better to require all teams to come to a walk there than to remedy the defect by blasting out those picturesque rocks.
>
> Forested areas at Apollinaris Springs, a point 8½ miles from headquarters, Crystal Springs, and at mileposts 13, 14 and 17 miles out should be cut back on the east side about 30 feet to expose the snow to the sun. However, if these forests contained fine specimens of trees, the stands should be preserved. The Apollinaris Spring, Kepler Cascade, Mud Geyser and other coach unloading platforms should be rebuilt and extended to a length of 100 feet.[17]
>
> The first hill just beyond the Growler can probably be brought to the adopted grade of 8 percent by a small amount of cutting and filling and no relocation of the old road is deemed necessary. The second hill just beyond the first milepost can probably be dealt with better by going around it to the south. A personal reconnaissance of the ground indicates the entire practicality of such a line. If built, it should leave the present road at the foot of the first hill near the Minute Man Geyser and rejoin near the foot of the second hill at the beginning of the tangent across Elk Park.
>
> The maintenance of the retaining wall along the Gibbon River between Elk Park and Gibbon Meadow can probably be avoided advantageously by putting the road back farther into the rock. If the wall is retained it will have to be relaid in mortar.

First Lieutenant Ernest Peek, who replaced Chittenden, agreed with Chittenden's suggestions, and began repairs on the drywalls near Gibbon Falls in 1907. In order to efficiently coordinate the work on this section, Peek established a number of road camps including one near Obsidian Cliff and one near Beryl Springs. The camps had frame tents.[18] In 1908 Peek requested sufficient funds to purchase three bridges, including two for Gibbon River, but his request was not honored. Thus, very little major work occurred, but road surfacing was carried out from Silver Gate to milepost-5 across from Swan Lake Flats. Near Crystal Spring, "considerable work was done on the roadside in order to deepen the ditches and give the road a good high crown. Surfacing was also done on the Norris to Fountain road from 2½ to 2¾ miles. The 25-foot bridge at Obsidian Cliff and the 15-foot bridge at Apollinaris were each replaced by fill with 4-foot culverts. At Obsidian Cliff, the road was straightened and raised over 2 feet.[19]

In 1909 Army Captain Willing conducted an inspection of the bridges in the park, and made a written report of their condition and recommendations for improvements. On this section of the road, Willing found:

> Bridge No. 2 across the Gibbon River, 5¾ miles south of Norris Station--The present structure consists of one wooden span with two wooden approaches, and was built in 1895. The timber in the bridge is sawed pine lumber, which at present is in a decaying condition, some of the floor beams being broken and held in place by props. The structure is in an unsafe condition, and it is recommended that it be replaced by two 50' low truss, pin-connected steel spans, resting on two concrete abutments and one concrete center pier.
>
> Bridge No. 3, Gibbon Canyon Bridge, across Gibbon River, 7 miles south of Norris--The present structure is a trestle bridge 80' long, built 1891, of sawed pine timber which is in a decaying condition. It is recommended that this bridge be replaced by an 80' low truss, pin connected steel span, resting on concrete abutments. As the bridge crosses the stream, at an angle of about 45 degrees, it will be necessary to make this bridge askew.
>
> Bridge No. 4, Gibbon Canyon Bridge, across Gibbon River, 9 miles south of Norris Station--The present bridge consists of two piers in the stream, two abutments of logs, and log stringers spanning the space between these piers. It was built in 1892, is 65' long is in shaky and decaying condition. It is recommended that it be replaced by a 65' low truss, pin connected steel span, resting concrete abutments. It will be necessary that this bridge also be built askew as the road crosses the river at an angle of about 45 degrees.
>
> Bridge No. 5, across the Gibbon River at Wylie's Lunch Station--The present structure consists of one pier in the middle of the stream, and two log abutments with log stringers spanning the space between. The bridge was built about eight years ago and is in a fair condition, but two light in construction for the travel it has to carry. It is recommended that it be replaced by a 40' steel plate girder span, resting on concrete abutments.
>
> Bridge No. 7, at the mouth of the Gibbon River, near the junction with Firehole River--The present bridge consists of one wooden span with approach at one end, resting on wooden piers and

> abutments, total length 66'. This bridge was built in June and July 1896, and is also in the advanced state of decay and is unsafe. It is recommended that this bridge be replaced by a 65' low truss, pin connected steel span, resting on concrete abutments.[20]
>
> During 1909, the road between mileposts 8 and 15 was ditched and crowned and the road was raised about 1½ feet at the culvert fill across Willow Creek. The ruts caused by heavy traffic and water were filled with surfacing material.[21]

In 1911 the road from Gardiner to Norris Junction was regraded and twenty-one miles graveled. Also that year, the engineers recognized the need to replace a section of dry rubble wall along Gibbon River.[22] During the winter of 1912, Captain Knight recommended that additional dry rubble guard walls be built on the outside edges of curves through the Golden Gate. He suggested the road along Gibbon River between points 8 and 9 be raised 2 feet for 1½ miles to keep it from overflowing in the spring, and that sections of the dry rubble retaining walls be rebuilt.[23] He also felt that the old, crumbling retaining wall between Norris and Fountain should be replaced and that the narrow road should be widened.[24]

In 1914 gravel was placed over the middle 8'to 10' of the Golden Gate to Swan Lake Flats road to bring up the crown and fill in the wagon ruts. The gravel, which was taken from a pit just east of milepost-4 was loaded through a trap by drag scrapers. It took approximately one-quarter yard of gravel per linear foot of road.[25] Some of the old bridges between Mammoth Hot Springs and Madison Junction were replaced during the year. A two-span reinforced concrete bridge was built over Gibbon River seven miles from Norris, and one 65-foot single-span girder and slab bridge was built over Gibbon River near its confluence with Firehole River. A 40-foot steel arch bridge was built over Gibbon River near Wylie Camp, seventeen miles from the west park entrance. More reconstruction of stone retaining walls was done in Gibbon Canyon and the road crews built a barn at Gibbon Meadows camp, a cabin at Beaver Lake camp, and two "public-comfort houses" at Norris Geyser Basin.[26] No major road projects occurred on this section of Grand Loop Road for a few years.

Shortly after the National Park Service was created, Secretary of the Interior Franklin Lane visited the Yellowstone. During his inspection of the road system, he recognized a safety and visual problem in Gibbon Canyon, the growth of small trees along the road. He found that the trees obstructed the view of the river and made for dangerous driving conditions. He also felt the removal of a few trees at Gibbon Falls would afford "a better view of the falls." Lane's other comments on road conditions included:

> On top of hill on main road two miles from Mammoth a number of very bad and hard rolls and bumps. Two serious holes more than half way across Swan Lake Flats. Bridges at Upper Gardner River, Willow Creek and Gibbon River at Norris, below and above road levels. Road at Roaring Mountain in poor shape. Road Norris to Fountain down the Gibbon Canyon very rough, full of large chuck holes and broken culverts. Also contains one or two improvised log bridges where culverts have been washed out. Wylie Gibbon Camp over Mesa Road to Firehole River, about four very bad chuck holes that could be filled with little expense.[27]

During 1921 a new steel and concrete bridge was constructed over Gibbon River near

Norris, and wooden mess halls were built at Madison Junction and at Gibbon Meadows.[28] For the next few years, small allotments financed minor road projects, mostly accomplished on short sections at the end of the season. In September 1927 a crew composed of men and teams from disbanded work groups, began a grading project along Gibbon River. The 1928 appropriation provided sufficient funds for an entire season of work. Foreman John Benson established a temporary work camp at milepost-17 on May 17, in order to begin the heavy steam shovel work in rock cuts and to arrange detours for traffic. Later the camp was moved to Norris Junction. The project was completed in May 1929.

In June 1930 Foreman O.A. Weisgerber established a camp at the old Beaver Lake road camp in order to begin work on the Bijah Springs-Obsidian Cliff section. A dangerous curve was reconstructed near milepost-15 and between the Gardner River crossing and the Glen Creek crossing. The crews were stalled by underground springs which required the installation of subdrainage. Material from a rhyolite slide north of Obsidian Cliff was used for a rock sub-base. An Osgood gas shovel, which had been moved up the Gibbon River-Norris Junction section was used on this section. The next section mostly required light cuts in the existing roadway and side cuts to straighten and widen the road. On this section, the banks were sloped up to an 8- or 10-foot cut on a 1½:1 and 2:1 slope. It was felt that the slopes, which would present a pleasing appearance, would also suffer less erosion from heavy runoff and the vegetation would take root easily. Upon completion of the excavation of this segment, the shovel removed rhyolite material from a pit behind the Norris Ranger Station for use as a light coating material for surfacing. The camp was dismantled in November.[29]

In October 1929, when the weather became too bad to work in the interior of the park, crews resumed work on 600 feet of road in the Mammoth Lodge area. Most of the project was infill, but the additional rough fill material needed was obtained from the demolished concrete granary near Tower Falls and Mammoth Hot Springs junction and from abandoned concrete flumes near Mammoth Lodge. Removal of these structures were part of the Landscape Division's plan for the Mammoth area. The rough fill was covered with material obtained from the road slopes above Mammoth Reservoir and finer material for surfacing came from the pit on Capitol Hill. In addition to road construction, the old wooden sidewalk and gravel walk to Mammoth Lodge was replaced with a stone curb sidewalk. The new sidewalk was described as:

> a stone curb walk, 2,412 feet in length, and with an emulsified asphalt surface. Curbing, of locally quarried sandstone, is twelve inches wide and with a clear face of eight inches on the street side. Width of walk between curbs is five feet, an overall width of seven feet. The space between curbs was filled to within three inches of the top with any available material. Above this was spread two courses of grade size gravel, each coat being sprayed with a penetrating coat of Bitumuls and rolled to a true cross section. A final coat of fine native sand was then broomed into the surface, giving a natural gray finish to the walk.[30]

After the Bureau of Public Roads (BPR) assumed responsibility for road construction and maintenance in the national parks in 1926, the Mammoth Hot Springs to Madison Junction road was the first major project considered, however, adequate funding for location surveys were not received until 1929-30, so the lower segment of the section was constructed by National Park Service laborers. The location survey for the Mammoth Hot Springs to Obsidian Cliff segment was made in the fall of 1930. At that time additional funds were requested for designs for a new viaduct at Golden Gate.

A better route south from Mammoth Hot Springs was investigated, but an improved route through Golden Gate was deemed more advisable than the old route through Snow Pass and Bunsen Peak, or a proposal by the park's engineering department for a higher location through Golden Gate Canyon toward Mammoth Hot Springs through the Hoodoos. The National Park Service's Landscape Division did not approve of cutting.

The route proposed by the BPR followed the older Army Corps road from Mammoth Hot Springs south, except at the Gardner River crossing and the Obsidian Creek crossing, where it moves approximately one-quarter mile eastward for a distance of about three-quarters of a mile. The location report described the condition of the road and proposed changes:

> The present road follows the left bank of Obsidian Cliff at the foot of steep talus slopes in a narrow confined canyon. The alignment is fairly good, consisting of 4 degree to 6 degree curves, all to the left, connected by short pieces of tangent. The grades are easy but rolling. In the relocation these curves were all combined into two simple curves with 500 feet of tangent between them, and the grades were made more uniform. Some bank protection is required in a few places along the creek but as this stream is not subject to wide seasonal variations and high velocities this item is of minor importance.
>
> At station 25+00 a fine spring of good water arises under the roadway and will have to be kept open by the use of a special drainage structure. At about this point the creek swings eastward away from the road and the new location which, continuing on a long flat curve initiated in the canyon, ascends gently to a very low timbered bench and thence proceeds across the bench; at about station 40+00 it descends slightly to a lower bench and at station 41+50 passes a greatly admired lily pond. At about station 63+00 the creek swings in from the east and meanders extensively on the east of the road which finally crosses it at station 65+00.
>
> At station 69+00 the present road passes Apollinaris Spring, a natural mineral spring which has been developed by the Park Service to form the main point of interest between Obsidian Cliff and the Golden Gate. The new location is here identical with the present road except that the grade will be laid one or two feet lower and the fill on each side of it two or three feet higher to reduce the hump existing in the present road. Poor surface drainage from the spring as far as station 76+00 has resulted in seepage softening the roadway subgrade. A higher embankment and better drainage will be necessary to overcome this difficulty.
>
> From the spring onward the present road and new location follow along the gently sloping timbered slopes on the east side of the creek. The creek meanders through a willow covered flat on the left which is rather wet swampy. From station 88+00 to 104+00 the present road crosses or follows the edges of a series of boggy swamps or marshes caused by springs on the hillside to the east, which is here steeper and more in evidence than at any place since leaving the canyon at station 25+00. The roadway here is cracked and moves under the wheels of passing cars and trucks and entire reconstruction down to solid material is required. If this is undertaken on the present road handling of traffic during construction will be a different matter. To facilitate the handling of traffic and at the same time reduce curvature the new line was laid up into the marshes between station 88+00 and 95 and stations 99+00 and 103+00 and out into the creek bottom marsh between station

95+00 and 99+00. Through these marshes it will be necessary to excavate from two to four feet of unsuitable material below the grade, which has been laid low to facilitate this process, and to provide tile cut-off drains on the upper side of the roadway.

From station 103+00 ahead, the present road follows along the generally lightly wooded, and gently rolling slopes on the east side of the creek with the willow bottom land on the left. These willow bottoms are attractive to moose, which may very frequently be seen there by those passing on the road. Only slight changes in line and grade are introduced into the route by the new location from station 104+00 to station 210+00. At 210+00 the present road curves quite sharply left to cross Obsidian Creek and then follows along the edge of the woods on flat gravel bottom land to a crossing of the Gardner River, about a quarter mile further ahead, whence it ascends immediately to the bench land above. To avoid the sharp curvature approaching the present Obsidian Creek Bridge, and the reverse curve beyond it, a new location for this piece of line was sought.

Several routes were investigated one of which would not have rejoined the present road before reaching the head of Golden Gate Canyon. This one was rejected because of the value of the investment in the present road. Another route was investigated which swung over to the east side of the river bottom and crossed the Gardner River below its point of confluence with Obsidian Creek, thus eliminating one bridge. This route did not at first meet with the approval of the Landscape Division of the Park but was later approved and run as alternate and recommended for construction. The third route investigated ran down the middle of the bottom land making use of a gravelly wooded low ridge and crossed both Obsidian Creek and the Gardner River in favorable places. It was finally rejected by the Landscape Division because of its position in the middle of the river bottom.

Both these latter routes rejoined the present road in about the same place, station 250+00, whence the new location again follows the present road very closely over a rather untimbered gently rolling ridge to station 305, the beginning of Swan Lake Flat. At station 289+00 the Mammoth domestic water supply line crosses under the present road thence parallels it on the east to the head of Golden Gate Canyon where it empties into Glen Creek and descends through the Canyon as part of the creek.

The present road across Swan Lake Flat station 305 to station 406, has been built up on a fairly stable fill. The flat is, in fact, a sagebrush covered marsh with a gravel bottom, overlaid with gravelly clay and humus accumulations. It seemed wise to make use of the embankment already in place and the new location was run accordingly. Provision was made in the estimate for removal and replacement of unsatisfactory material. Between station 300+00 and 315+00 a curve on the present road was eliminated by continuing the tangent behind station 300+00 to 312+50.7 where it curves right to rejoin the present road. Two crossings of the water line were made necessary by this change. Swan Lake, about 80 acres is extent, lies in the western half of this marsh. Its shores are swampy and, as the lake level is only three to four feet below that of the road, it is not very noticeable to those driving through. Occasional moose are seen along its shores and a pair of swans are sometimes seen on its waters. The high snow covered mountains rising above the flat to the southwest, west and northwest, together with the marshes and the wild life they suggest, gives it a decidedly Alpine feeling.

The road now enters Golden Gate Canyon, so-called because of the yellow lichen growing on the canyon walls, and, passing Rustic Falls on Glen Creek at the head of the Canyon, station 413, begins rapid descent into the Gardner River Valley. From station 413+00 to 426+00 it is benched into basalt cliffs or supported, on steep slopes, against the cliffs by rock walls and a viaduct. Thence it descends along less steep and rocky slopes through pine timber on easier grades but crooked alignment to about station 445+00 where it enters an area of topsy-turvy limestone rock fragments, apparently the result of a tremendous slide or breakdown of Terrace Mountain to the West. The new location begins descent at Rustic Falls using 1,000 feet of 7 percent grade to bring the grade of the proposed road as close to that of the present viaduct as possible. At about station 419+00 to 420+00 a one hundred foot tunnel through a badly fractured basalt point is proposed to eliminate a very sharp curve in the present road; and from about stations 422+00 to 427+00 masonry retaining walls and a viaduct are proposed to pass the high cliff between those points. The Bureau strongly recommended that the road be benched into the cliff between these stations but the Landscape Department of the Park Service would permit no scarring of this cliff. The proposed viaduct would be about 300 feet long, a little longer than the present one, and can probably be designed to use or at least hide the present structure. As extensive foundation investigations were made as was possible with the crew and equipment at hand and the time available.

Just beyond the end of the viaduct the present road curves left and heads a steep short draw. The new location was run across the draw. The new location was run across the draw to improve the alignment and provide a place for material excavated along the cliffs. It crosses the present road at about 431+50 and thence occupies new country to the left of and higher than the present road thereby greatly improving both alignment and grade. It does not again follow the old road, though crossing and recrossing it in several places, until station 528+00.

At station about 450+00 the new location enters the Hoodoos, traversing this area on alignment and grade agreed upon during a joint investigation between Bureau representatives and the Director of the National Park Service in person, as well as local representatives of the Park. The irregular shapes and freakish positions of the rock fragments, together with the grotesque and ghoulish atmosphere conferred by the dead trees and unnatural position of the rocks, makes this area one of considerable interest and of considerable importance to this Park. Development of this area in a manner satisfactory to the Park Service was a major control in the relocation of this road. The Silver Gate, a closely walled-in, sharp, blind, curve, highly regarded by the Park Service for its harmony with other formations in this area and forming the southern entrance into the heart of the Hoodoos, could not be incorporated into a standard road and had to be eliminated; however a thirty-five foot through rock-cut, on the new location about opposite the Silver Gate, station 465+00, necessary for good alignment, forms an admirable substitute for this gate as an entrance into this area. Furthermore, it is planned to leave the present road between 461 and station 464+50 as a side road for the benefit of those desiring to use the Silver Gate.

From this point ahead the new location descends as rapidly as possible along the steep, rocky and partly timbered mountainside, using one 200 ft. radius curve of 153 degree angle around the sharp point at station 476 to station 481. Between station 488 and station 495 it follows along a steep east slope close enough below the present road to practically accomplish obliteration, finally crosses it below grade at 496+50, returns to it at station 500 and thence follows it to station 505 where it again leaves the present road on its right and continues descent to 508. From station 508 to station 530 the new line rather roughly parallels the present road, descending on slack grades as far as station 520+00 and thence on 5 percent and 6 percent grades to the end of the project at station 545+00 BPR = 986+38 NPS. The new location follows the present road closely from station 530+00 to the end at station 545+00.[31]

The 18-foot standard roadway design by the Bureau of Public Roads was used on this road segment. The design provided an 18-foot surfaced roadway with a 3-foot shoulder on either side, both on fills and cuts. Three-foot standard ditches, 1' deep with 2:1 slopes into the ditch, from the shoulder, were provided for sections in cuts. The cut slopes were designed for slopes 1:1 or flatter in common material as specified by the Landscape Division of the National Park Service. For the use of materials other than common, the cut slopes were designed at slopes thought to be stable for the particular material, except that all cuts 4' were designed with one to one slopes. The fill slopes were all designed at 1½:1.

The BPR called for the use of corrugated, galvanized metal pipe culverts with cement rubble headwalls for the minor drainages and for reinforced concrete box culverts with cement rubble headwalls for creek crossings. They also recommended the construction of a reinforced concrete structure 75' or 80' long of two or three spans at the crossing of the Gardner River at station 233+50.

In assessing the Golden Gate viaduct situation, the BPR found the present viaduct below the grade of the located line and too narrow thus, a new a new viaduct was necessary. In order not to incur further scarring, a wider and slightly higher structure was needed. They recommended cement rubble retaining walls on either end of the viaduct and the respective length of the wall. The new reconstruction would also require a tunnel approximately 100 feet in length.

Finding snow conditions worse in the Swan Lake Flats area, snow fences were suggested to control the conditions on the flats. The BPR did not project possible snow conditions at either entry to the tunnel, but they tried to consider snow problems on the route in case of possible winter use of the road.

A sand and gravel pit on Swan Lake Flats was approved for concrete aggregate material, but its conspicuous location limited the amount that could be extracted from it.[32] Following the completion of the location survey, the Denver office of the BPR designed the road and also the plans and specifications for Seven Mile Bridge over Gardner River. The BPR's plans designated grading and draining on an 18-foot 1930 standard roadway width. Concrete box culverts and corrugated metal pipe were designed for drainages; tile drains and rubble drains were planned for wet and swampy areas.

Following the advertisement for bids in the *Rocky Mountain News* (Denver), the *Billings Gazette* (Billings, Montana), and the *Salt Lake Tribune*, Stevens Brothers of St. Paul, Minnesota, was awarded the contract with a bid of $140,126.65 (73 percent of the engineer's estimate). The contract was awarded on August 5, 1931, and the contractor set up camp immediately and began construction work on August 13.

Three camps were use for this contract. During 1931 the camp near station 55, or near Apollinaris Springs was used, then moving the camp to station 300 at Swan Lake Flats in October, 1931. For the remainder of construction, the contractor used a camp near station 515. These camps consisted of portable cabins positioned on wheels for cook houses, office and bunk houses, and tents to accommodate extra crews. The average daily crew working on the project was 57 men using the following equipment:

3 -- "60" Caterpillar tractors
2 -- Hydraulic Bodies
2 -- Hydraulic Fresnos
1 -- Concrete mixer
1 -- Hydraulic Bulldozer
1 -- Hydraulic scarifier
1 -- Elevating Grader
14 - Teams with dump wagons
1 -- 1½-yard gas shovel
4 -- 3-ton dump trucks
4 -- 1-ton trucks
1 -- Grader, 12' blade
1 -- Compressor
1 -- Small electric light plant[53]

One of the firm's partners, C.R. Stevens, served as superintendent of the project. Using mostly long-time employees, he also hired common laborers locally. The foreman was paid $140 per month; skilled laborers, $100-140 per month; common laborers, $55 per month. The contractor gave a $45 per month subsistence sum.

During the 1931 season grading began at a point south of Obsidian Cliff and in 2½ months had progressed to station 245 near the crossing of the Gardner River, but cold weather forced the crews to move toward the other end of the project near Mammoth. Prior to shutting down for the winter, all concrete work had been done, the Seven Mile Bridge begun, some masonry work finished and the drainage projects completed as the grading progressed.

The contractor started the 1932 season on May 12, with shovel and dump trucks working in the Hoodoos. Extensive blasting was required to break up and loosen the huge wedged rocks, then more blasting was needed to break the rocks into manageable pieces for hauling. Grading continued on the project until August. During the 1932 season, Seven Mile Bridge was completed, pipes, head walls, and rubble drains, were completed as grading permitted, and an old road was obliterated. The old road from station 465 to station 496 required tearing out old retaining walls, cutting of the old shoulders, and hauling out the waste material. The new road approximately paralleled the old road.

Two concrete box culverts were installed, one 8'x6' at station 64, the Obsidian Creek crossing and one 8'x4' at station 369, the Glen Creek crossing. Corrugated metal pipes with masonry headwalls were installed over the other drainages. Tile and rubble drains and rock sub-base were installed in the swampy ground in areas of springs. The project required the installation of 1,922 feet of tile drain and 5,955 feet of rubble drain.

The types of material the grading crews faced throughout the project were varied. From just south of Obsidian Cliff to near the Glen Creek crossing, the cuts were through solid rock, loose rock, gravel, muddy swamps and common earth. From the Hoodoos to the end of the project at the Mammoth Terraces, cuts were through solid rock and very large loose rocks, with some common earth and gravel toward the end. Since the park required that all borrow pits should not be visible from the road, the contractors experienced some difficulty in finding suitable material within a reasonable hauling distance.[34]

The engineering crews occupied three portable cabins built by the contractor at the National Park Service's Beaver Meadow maintenance camp during 1931, then moved to Mammoth Hot Springs until the end of the project. In addition to retracing the center line and cross-sectioning the entire project, staking culverts and drains, the engineers placed concrete center-line markers at intervals of approximately one-half mile over the entire project. A light palliative oil treatment, 4,000 gallons per mile, was applied to the entire road to aid in the dust nuisance and serve as an interim measure until a surface course of crushed rock or gravel was applied. The project was completed by September 6, 1932, at a total cost of $136,810.94.[35]

Several landscape architecture issues were identified during 1932. During Mattson's inspection of the guard rail between Mammoth Hot Springs and Norris in July, he objected to the use of dark stain. The BPR said that the use of the stain resulted from competitive bidding and hoped that Mattson could work with the park to achieve the desired effect. After discussing the use of oil to thin the stain, Mattson was assured that the stain would bleach to a lighter shade. However, in discussing the staining of the guard rail at Madison Junction, he asked not to stain the guard rail until it was complete and "then use every effort to obtain the original desired color."[36] Vista clearance and guard rail installation was also considered by the Park Service landscape architects in their July report:

> sta. 93--work will be done under road contract to provide turnout when waste material is cleaned up
> sta. 122--Road ditch to be filled making 10 ft. dalite available for distance of 100 ft. No guard rail required. Few trees to be selected and removed.
> sta. 125--Dalite already available between sta. 124 and sta. 126 needs oil surface and 150 ft. guard rail. Some trees to be removed.
> sta. 150 to 151--some trees to be removed-no turnout, no guard rail required. Vista will be available while autos are in motion.
> sta. 160--remove numerous matured trees at edge of meadow for vista. No parking required, no guard rail.
> sta. 173 to 175--This location is on the outside of a curve. It would require considerable yardage to fill three feet deep and ten feet wide. Guard rail would be required.
> sta. 185--Several dead trees and a few mature trees to be removed. No parking or guard rail.[37]

Upon completion of the segment between Mammoth Hot Springs and Obsidian Cliff, Seven Mile Bridge which the new road bypassed was removed by park crews and the old road obliterated. The new road location required removal of 5,460 feet of telephone lines. The 18-wire system was relocated through a 16-foot right-of-way in a wooded area.[38]

In October 1933, John McLaughlin of Great Falls, Montana was awarded the surfacing contract for the twelve (11.99) miles of road between Obsidian Cliff and Mammoth Hot Springs. Upon receiving the contract, McLaughlin set up camp about 600 feet to the right of station 520, a site which had been used by two previous contractors. McLaughlin purchased the frame buildings which the other contractors used for use as cook house, office, and bunk houses. He completed the camp by adding tents for additional sleeping quarters.

The crews began quarrying the widened heavy cut through solid rock in the Golden Gate between stations 418 and 421. The rock obtained from the high cliffs was blasted, put through a primary crusher and then stock piled to the left of station 409 at Swan Lake Flats.[39] The crews worked through the winter in order to avoid the traveling public during the visitor season. By the beginning of May 1934, sufficient rock was stock piled and some surfacing had begun. By July 17, the project was complete.

The finished roadway had a 22-foot shoulder-to-shoulder width, a 4-inch base of 1½-inch maximum size aggregate and 1-inch top of 1-inch maximum size aggregate. The earlier grading contract had graded the road on the 1929 standard, but on this project the superelevation on all curves conformed to the 1932 standard. The surfacing courses consisted of rhyolite. At the conclusion of the project, a palliative oil treatment was applied. A plant mixed oil course was scheduled for application during the summer of 1935.[40]

In October of 1934, Taggart Construction Company received the oiling and seal coat bid for $99,836.00. This project covered 36.29 miles of road, with 11.99 miles receiving a plant-mix oiled material and 24.29 miles receiving a seal coat. The contractor established his camp approximately 1000 yards left of the gravel pit which was to provide the surfacing material at station 255. A frame cook house was constructed, portable tents were used for bunkhouses and a portable building on wheels served as the office. The project required the services of about 65 men. A Pioneer Duplex crushing and screening plant was placed at the gravel pit which was approximately 1,000 feet left of station 260. The crushed and screened material was stock piled nearby.[41] The project began on May 15, 1935.

Upon the completion of oil matting, the crews built masonry guard rail, performed cut slope treatment, cleaned up any slide material, obliterated old roads and borrow pits, placed top soil and planted approximately 275 trees of which 28 died. Parking areas were constructed near the Beaver Dams at station 100, at Appollinaris Spring and Roaring Mountain. The Beaver Dams parking was considered by the engineers to be a "pleasing and useful asset to the road."

The project, which extended from Mammoth Hot Springs to Firehole Cascades, was completed on September 30, 1935. With the exception of construction or replacement of four bridges over Gibbon River, "The smooth, wide highway, with easy curves and grades, should add greatly to the comfort and safety of the increasing volume of tourists who come to visit Yellowstone National Park each year."[42]

With the exception of bridge construction along this route, no major work was completed on the road until 1948 and 1949 when the road received another bituminous seal coat surface. The project, classified as a maintenance project and financed with park funds, was awarded to Peter Kiewitt Sons Company of Sheridan, Wyoming, at a cost of $77,250.00. The park hoped that this treatment would extend the life of the existing pavement and lower the cost of maintenance on this road section. The crushed and screened material was stockpiled at locations along the route, however, the bituminous material was trucked in directly from a refinery at Cody, Wyoming. Most of the equipment and supplies were brought in from West Yellowstone or Gardiner, Montana. In order to transport the crushing and screening plant over Madison River Bridge, the span had to be reinforced with the addition of eight temporary timber bents. The project was completed on August 2, 1949.[43]

The next major road project between Mammoth Hot Springs and Firehole Cascades was the construction of the Norris Junction bypass, a project initiated by the National Park Service's Mission 66 program for Fiscal Year 1965. The 6.32-mile project channelized the intersection for Grand Loop Highway and the Norris-Canyon Cutoff. The new alignment was intended to bypass Norris Museum and Norris Geyser Basin and reduce the traffic congestion in that area.

Plans for the bypass were designed in the Region 9 Federal Highway Administration Office during the winter and spring of 1964-65. Both aerial and ground survey methods were used in siting the new alignment and automatic data processing equipment was used in its design.

The mainline roadway was designed for a 38-foot graded width with a 5½-inch base. The upper 1½" of base were bituminous stabilized with a surface width of 30'. The two spur roads leading of the bypass were graded to a 32-foot width with a 5½-inch base of which the top 1½" was bituminous stabilized with a surface width of 24'. The shoulders were defined with cover aggregate resulting in a travel way of 22' on the main road and 20' on the spur roads. A 12-degree maximum curve, a 5.4-percent maximum grade, and minimum horizontal and vertical sight distances of 250' and 240', respectively, were other design features.

The contract was awarded to R.J. Studer & Sons of Billings, Montana, which submitted the low bid of $817,815.00. During May of 1966, subgrading began in an unstable, marshy area across from Elk Park, then moving on to a soaked peat bog near Gibbon River. In addition to the grading operation, corrugated metal culvert pipe, vitrified clay culvert pipe, and perforated corrugated metal pipe underdrains were installed. Drop inlets, headwalls, and concrete curb and gutters were installed in October 1966. By the end of October, the old road had been obliterated in the Norris Geyser Basin area, and the areas of old Gibbon River Bridge and old Norris Junction. Seeding was done in one procedure with a 1,200-gallon hydroseeder, seed, fertilizer, and green-dyed wood cellulose mulch. The one operation covered approximately a quarter-acre area. The guide posts treatment was changed from chemonite or greensalt to pentachlorophenol which produced a brown, rather than green, color. Other landscape details required the coloring of visible portions of concrete box culverts to be the same color as the curbs and gutters and, the removal of downed trees along part of the route. The crushed aggregate came from a pit sited to the left of station 1362+50 on Route 12, the Northeast Entrance Road,the material came from an alluvial deposit and some from a highly disturbed rhyolite formation next to the alluvial deposit. A pit at Corwin Springs, Montana provided the concrete aggregate and the cement came from the Ideal Cement Company at Three Forks, Montana. Almost all of the corrugated metal pipe, which was spot welded, came from the Bethlehem Steel Corporation. The contractor completed the project on November 7, 1966.

Upon its completion, the route provided safer passage through this area. In the past, a common complaint and worry to park officials was the reduced visibility caused by steam blowing across the road from the geyser basin. Automobiles, pulled off on the shoulder for better geyser viewing, also caused a safety hazard. One recommendation the officials made at the of the project was that the roadway receive a high-type bituminous surface at some time in the future to replace the 1½-inch thick plant-mix base which had been applied as a temporary measure.[44]

DESIGN AND CONSTRUCTION OF SEVEN MILE BRIDGE

Completed in 1932, Seven Mile Bridge was designed by the Denver office of the Bureau of Public Roads and built by Steven Brothers of St. Paul, Minnesota. The bridge carries Grand Loop Road over Gardner River, 9.5 miles south of Mammoth Hot Springs. The concrete girder bridge, with masonry piers and abutments, has three spans with a maximum main span length of 27' from center of support to center of support. The flanking spans are 23' and 25', respectively. The deck width is 27'-0", while the bridge roadway, curb-to-curb, is 24'-8" wide. The cost of the bridge was $150,000.22.[45]

The design load for the bridge was 15 tons. All concrete was Class "D" with a maximum aggregate size of 1½". Class "D" refers to the proportion of cement in the mix. All exposed corners were chamfered ¾". The top of the slab has a superelevation of ½" per foot. The roadway center line curves to the left 4 degrees 18.7 minutes as one looks south. The slab is 2½" thick. Transverse reinforcement at the top and bottom of the slab consists of ⅝-inch deformed bars at 14-inch centers. The ⅝-inch diameter bars bent up over the longitudinal girders are located between the other transverse reinforcement at 14-inch centers also. Longitudinal reinforcement in the slab consists of ½-inch diameter bars at about 10" on center.[46]

Seven Mile Bridge has eighteen simple, concrete girders arranged in six rows spaced 5'-1" on center. All girders are 2' deep. The outside girders and middle six girders are 1'-5" wide while the other six girders are 1'-1" wide. All girders have transverse ⅝-inch diameter stirrups. The spacing between these stirrups in the middle girders ranges between about 8" near the piers and abutments to 1'-6" away from the piers and abutments. The closer spacing near the piers and abutments takes up the additional shear found here. The spacing in the outer six girders is uniform at 1'. The girders also have longitudinal reinforcement. In the middle six girders are eight 1¼-inch bars arranged in two rows near the bottom of the stirrups. In the outer six girders are three 1¼-inch bars and two 1-inch bars arranged in two rows near the bottom of the stirrups. There are also two 1¼-inch bars at the top of the stirrups in the outer six girders. The remaining six girders have six 1¼-inch longitudinal reinforcing bars arranged in two rows near the bottom of the stirrups. The girders flare downward in a V-shape over the piers and abutments. Hooked reinforcing bars are found in this area.[47]

The form lumber for the exposed faces of the six outside girders was of a single slab per span. This form lumber was sand blasted to expose the full grain of the lumber. A single piece of lumber with the same grain treatment was used for formwork on the outside of the flare V-shaped concrete extension over the piers and abutments. A V-notch made with two pieces of 3/4 inch chamfer strip was used to mark the flare V-shaped concrete extension from the rest of the girder on its exposed face. All forms were lightly oiled with raw linseed oil.

Transverse stiffeners were employed in this bridge in the form of concrete beams at either end of each span. Over the piers these beams are the same depth as the girders while over the abutments they are seated in the abutment. Over the piers these beams are reinforced with ½-inch diameter stirrups and two ¾-inch diameter bars at the base of the stirrups running the length of the beams. Over the abutments these beams also have reinforcement. The piers and abutments of Seven Mile Bridge carry the bridge on a skew. The superelevation of the bridge is built into the piers and abutments. A concrete seat, 2'-6" wide, 1' deep, and 28'-3" long, was laid in the piers which are battered at 1:12. A concrete seat, 1'-6" wide, 1' deep, and 27' long, was laid in the abutments which are battered 1:12 towards the stream and 4:12 away from the stream. The wing walls are flared and batter 1:12 on the outside and 3:12 on the inside. They extend 10' to 20' from the abutments.

The guard rail consists of 24"-diameter wood posts rising from the abutments and piers with two 12"-diameter posts on each span rising between these larger posts from the slab. The 12"-diameter logs span on top of these 12"-diameter posts and frame into the larger post. A wheel guard made of half of a 12"-diameter log runs at the top of the slab between posts. The guard rail is held together by bolts and threaded rods countersunk and plugged.

The estimated material quantities used in construction of the bridge were as follows:

Class "D" Concrete	105 cubic yards
Reinforcing Steel	26,500 lbs.
Masonry	340 cubic yards
Structure Excavation	450 cubic yards
Timber Rail	202 linear feet[48]

ENDNOTES

1.Philetus W. Norris, "Report Upon the Yellowstone National Park for the Year 1877, to the Secretary of the Interior," (Washington D.C.: Government Printing Office, 1877) p.841.

P.W. Norris, "Report Upon the Yellowstone National Park for the Year 1878," p.979.

2.Norris, "Report Upon the Yellowstone National Park for the Year 1878," p.979-80.

3.Herman Haupt, The Yellowstone National Park (New York: J.M. Stoddard Co., 1883) p.49.

4.Norris, p.980.

5.Norris, "Report Upon the Yellowstone National Park for the Year 1879," p.7.

6.Norris, "Annual Report of the Superintendent of Yellowstone National Park for the Year 1880," (Washington D.C.: Government Printing Office, 1881) p.13.

7.P.H. Conger, "Annual Report of the Superintendent of the Yellowstone National Park to the Secretary of the Interior for the Year 1882," p.5.

8.Conger, "Annual Report of the Superintendent of Yellowstone National Park to the Secretary of the Interior for the Year 1882", p.6.

9.Captain Moses Harris, "Annual Report of the Superintendent of Yellowstone National Park for the Year 1888," pp.7 and 12.

10.Major Charles J. Allen, "Annual Report of Major Charles J. Allen, Corps of Engineers, Officer in Charge, for the Fiscal Year Ending June 30, 1889," p.2863.

11.Captain F.Q. Boutelle, "Report of the Superintendent of the Yellowstone National Park, 1890," pp.8-9.

12.Captain George Anderson, "Report of the Acting Superintendent of Yellowstone National Park to the Secretary of the Interior, 1895," p.8.

13.Hiram Chittenden, "Roads in Yellowstone National Park," Senate Document 226, 50th Congress, 1st Session, 1900.

14.Chittenden, "Annual Report Upon the Construction, Repairs, and Maintenance of Roads and Bridges in the Yellowstone National Park and Construction of Military Road from Fort Washakie to Mouth of Buffalo Fork of Snake River, Wyoming and Erection of Monument to Sergeant Charles Floyd in the Charge of Hiram Chittenden, Captain, Corps of Engineers, Being Appendix FFF, III, and JJJ of the Annual Report of the Chief of Engineers for 1901," (Washington D.C.: Government Printing Office, 1901) p.3780.

15.Hiram Chittenden and John Mills, "Annual Report Upon the Construction, Repair and Maintenance of Roads and Bridges In the Yellowstone National Park and the Road Into Mount Rainier National Park; Survey for Wagon Road From Valdes to Fort Egbert, Alaska, and Survey for Military Trail Between Yukon River and Coldfoot, Alaska, Being Appendixes FFF and KKK of the Annual Report of the Chief of Engineers for 1904," p.4174.

Chittenden and Mills, "Annual Report Upon the Construction, Repair and Maintenance of Roads and Bridges In the Yellowstone National Park and the Road Into Mount Rainier National Park, 1905," p.2811.

16.See HAER WY-46, Golden Gate Viaduct.

17.Chittenden and Mills, "Annual Reports Upon the Construction, Repair, and Maintenance of Roads and Bridges in the Yellowstone National Park and the Road Into Mount Rainier National Park Being Appendixes FFF and KKK of the Annual Report of the Chief Engineers for 1905," p.2820.

18.Ernest Peek, "Annual Report of the Chief of Engineers for 1907," (Washington D.C.: Government Printing Office, 1907) pp.2821, 2466 and 2467.

19.Peek, "Annual Report of the Chief of Engineers for 1908," p.2547.

20.Wildurr Willing, "Report of Inspection of Bridges in the Yellowstone National Park, made September 24, 25, and 26, 1909, with recommendations by request of Captain Wildurr Willing, Corps of Engineers, U.S.A."

21.First Lieutenant Wildurr Willing and Major C.W. Kutz, "Report Upon the Construction, Repair, and Maintenance of Roads and Bridges in the Yellowstone National Park ... for 1909," p.2511.

22.Captain C.H. Knight, Major J.B. Cavanaugh, and Major Jay J. Morrow, "Report of the Chief of Engineers for 1912," (Washington D.C.: Government Printing Office, 1912) p.3031.

23.Knight to Chief Engineer, Army Corps of Engineers, 12 February 1912.

24.Knight to Chief Engineer, Army Corps of Engineers, 19 February 1912.

25.Major Amos Fries, "Report to the Chief Engineers for October, 1914."

26.Major Amos Fries and Major Jay J. Morrow, "Report Upon the Construction, Repair, and Maintenance of Roads and Bridges in the Yellowstone National Park; and Report Upon Crater Lake National Park, Appendixes EEE and FFF, 1914," pp.3393-95.

27.Chester Lindsley, Office of Superintendent, Yellowstone National Park, to Captain John Schultz, 9 October 1917.

28."Report of the Director of the National Park Service to the Secretary of the Interior for the Fiscal Year Ended June 30, 1921 and Travel Season 1921," p.169.

29.C.A. Lord, "Final Report Mammoth-Norris Road Project #502."

30.Ibid.

31."Roads - Construction (Terraces to Obsidian Cliff) Project 1-A-1 and 1-A-3," Yellowstone National Park Archives, File No. 332.1.

32.Untitled document, probably a location survey report for Obsidian Cliff to Mammoth Hot Springs road section, Yellowstone National Park Archives, File No. 332.1, Firehole-Cascade-Old Faithful Section 1-C-2.

33.C.F. Capes, "Final Construction Report Project 1-A1, A3, Grading Mammoth Terraces - Obsidian Cliff Section, Grand Loop National Park Highway Yellowstone National Park, Wyoming," 19 June 1933.

34.Kenneth C. McCarter and Frank Mattson, Landscape Architect's Report, July 1932.

> July 6 - Permission was given to Mr. Anderson of the BPR to use the material which had been stocked piled near Sta. 70 for top dressing on the elimination of old borrow pits. Mr. McCarter located a borrow pit at sta. 300. Many borrow sites have been prospected on this job which have proved worthless, in one instance the material which had been borrowed had the tendency to air-slake after being put into the road. Much boulders or "nigger-heads" generally develop after the pits are opened which cannot be used in the base of the shallow fill across Swan Lake Flats. The relocation between sta. 300 and 315 to avoid the double crossing of the Mammoth water supply concrete pipe line was recommended by McCarter. The proposed location turns slightly to the left, following closer to the natural fringe of trees and then reverses with easy curvature to the right and ties in with the main line again. This change obliterates much of the old road by following the present road more closely which is very desirable from the landscaping viewpoint.
>
> July 10 - Mr. Toll phoned Mr. Wiggins regarding the water line at the borrowpit at sta. 370. Mr. Wiggins believed the pipe to be about 16 ft. underground. If 2 ft. of covering were left over the pipe it would be satisfactory to Mr. Wiggins to excavate the dike.
>
> July 12 - Mr. Anderson, BPR, resident engineer, asked for a relocation of borrow. The pit which had been prospected behind the old barns at the south end of Swan Lake Flats proved inadequate and of undesirable material.
>
> July 13 - Mr. Wiggins does not favor the suggestion of cutting the water pipe line at the borrow pit at sta. 370 and use the marsh as a channel from there to Rustic Falls. His reasons were that the water would spread over the marsh and form a wallow for elk. Channeling would probably cause ice problems and flooding.
>
> July 14 - The removal of the dike which supports the water pipe is still the controlling factor in the obliteration of this most unsightly borrowpit. It was decided that further borrow outside of the dike could be obtained with the prospect of future replacement of the pipe line. When the pipe line is replaced it

> can be located in the toe of slope of the road and the dike can be smoothed out. This will permit the blending of the slopes of the borrow pit into the side slopes of the marsh. The dike will then be the only unnatural feature remaining. ... McCarter recommends that when the entire line is replaced that the line through the dike also be replaced for emergency purposes and that the dike be eliminated. The pipe line proved to be about two feet below the surface so the dike could not be partially excavated. It will be rounded off and sloped to fit the new conditions as well as possible.

35.Capes, "Final Construction Report (1931-32) Project 1-A 1, A-3, Grading, Mammoth Terraces-Obsidian Cliff, Grand Loop Project, Yellowstone National Park, Wyoming."

36.McCarter and Mattson.

37.Ibid.

38.Lord, "Final Report Mammoth Terraces-Obsidian Cliff, Post Construction Project #558, 1933."

39.E.O. Anderson, "Final Construction Report, 1933-1934 on Project NE 1-A1, A3, A4, A5 Surfacing, Grand Loop Highway, Yellowstone National Park, Wyoming," 11 January 1935.

40.Anderson, "Final Construction Report, 1933-34 on Project NR 1-A1, A3, A4, As Surfacing, Grand Loop Highway, Yellowstone National Park, Wyoming," 11 January 1935.

41.E.O. Anderson, "Final Construction Report, 1935 on Project NR 1-A1, A3, A4, A5, Oiling , 1-A2, B, and C-1, Seal Goat, Grand Loop Highway, Yellowstone National Park, Wyoming," 11 January 1936.

42.Anderson, "Final Construction Report, 1935 on Project NR 1-A1, A3, A5, Oiling, 1-A2, B and C-1, Seal Coat, Grand Loop Highway, Yellowstone National Park, Wyoming," 11 January 1936.

> The bituminous surfacing had a thickness of 3" loose and a width of 22'. It was constructed on 5" loose thickness of crushed rock base course which had been placed the previous year. A prime coat of Liquid Asphaltic Road Material, type MC-1, was used on the base course where needed, however most of it was in excellent condition, thus little priming was needed. Crushed gravel consisting of fairly hard rhyolite boulders and pebbles with sand filter and a small amount of dirt was the aggregate. The bituminous material, which consisted of liquid Asphaltic Road Material, type NC-4, was added into the mixture at a temperature of 175 degrees, then transported to the road at a temperature of 210 degrees or more. The material set up very quickly. A seal coat, which consisted of Liquid Asphaltic Road Material, type RC-1, was then covered with a cover of stone chips which had been crushed to a maximum size of ⅝" from basalt slide rock. The color to the chips was a blue gray which lightened the road surface for night driving.

43.Anderson, "Final Construction Report (1948-49) on Grand Loop National Highway-Wyoming, Project 1-A, B, C-1 Reseal, Yellowstone National Park, Wyoming," 8 February 1950.

44."Final Construction Report (1965-1966) on Yellowstone National Park Project 1-A(1), B(1) and 12(1), Grading and Bituminous Stabilized Base, Grand Loop and Norris-Canyon Cutoff, Yellowstone National Park, State of Wyoming."

45."Seven Mile Bridge Inventory Report," National Park Service, U.S. Department of the Interior.

46."Plans for Seven Mile Bridge over Gardner River," Bureau of Public Roads, Department of Agriculture, 1931.

47.Ibid.

48.Ibid.